Could Terrorists or Thieves Get Weapons Usable Material from Research Reactors and Facilities?

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Abstract
There is a real danger that terrorists could make nuclear weapons from the weapon-usable highly enriched uranium (HEU) used in most research reactors (20 per cent or higher enrichment in U-235). Despite the long-standing efforts by the US to convert research reactors with HEU to non-weapon-usable low-enriched uranium (LEU) and take back the HEU it supplied over the years in the "Atoms for Peace" program, most research reactors around the world still operate with HEU instead of LEU, including those in at least 28 developing countries. Major US-Russian cooperative efforts to better protect the many HEU facilities in Russia have produced substantial improvements there and in other former Soviet republics. Russia, which has itself supplied HEU research reactors to other countries, is now starting an effort similar to the US take-back program. Except for a major new HEU reactor in Germany, no new HEU reactors have been built since these conversion programs began. But the remaining HEU for research reactors is probably the most widespread and most vulnerable to terrorists of any weapon-usable material in the world. It is often poorly protected from thieves and saboteurs because, among many reasons, there are no *required* international standards for protecting such reactors.

1. The danger posed by "loose" HEU from research reactors

The first U.S. nuclear weapon, the Hiroshima HEU cannon-type weapon, was so simple and obvious in design that it was not even tested to see whether it would work before being exploded over Hiroshima. South Africa's nuclear weapons were also of cannon – type design and not tested so far as is known. According to an interim report of the bi-partisan Baker-Cutler panel to the Department of Energy (DOE): "A nuclear engineer graduate with a grapefruit-sized lump of HEU…, together with material readily available on commercial markets, could fashion a nuclear device that would fit in a van …"[1] According to report by DOE:

> Several kilograms of plutonium, or several times that amount of HEU is enough to make a bomb. With access to sufficient quantities of these materials, most nations and even some sub-national groups would be technically capable of producing nuclear weapons….[2]

2. How difficult is it to steal HEU from research reactors?

Over the last decade, the total amount of HEU seized from illicit trafficking exceeded that of plutonium by over 100 times.[3] Indeed, HEU is more widely spread around the world, and probably less well guarded.[4] Some 20,000 kg of civilian HEU exists in 345 operating and shutdown research reactors in 58 countries, including at least 28 developing countries.[5] By IAEA estimates, 258 of these are shutdown, but many of these have HEU which has not been returned to its supplier and many of these did not operate long enough to make the HEU too hot to handle, certainly not for suicidal terrorists.[6] Arrest reports suggest that all but one of the recorded thefts of significant amounts of HEU took place in Russia, which has more research reactors than any other country.[7] One recent expert report suggests that "Russian stockpiles of HEU in small research facilities, with fewer resources for security, pose a more immediate risk of diversion" than the large amounts of HEU in Russia that have been removed from weapons.[8] According to DOE's 2003 budget request to Congress, HEU "civilian sites contain approximately 35 tons [35000 kg] of the most vulnerable, proliferation concern material. These facilities are located in densely populated areas throughout the Russian Federation and the Newly Independent States and are considered to be the most likely target for proliferants seeking weapon usable material through either abrupt theft or protracted diversion."[9] For example, HEU seized on 5 occasions in Europe is suspected of having been stolen from a civilian nuclear site in Obninsk, which, among other HEU facilities, has three research reactors.[10] Today, Russia has approximately 40 operational civilian HEU-fueled research and test reactors and critical assemblies.[11] The US-Russian Material Protection Control and Accounting (MPC&A) program has completed improvements at some of these HEU sites, is continuing in many others and may begin improvements at still others.[12] US-assisted conversion of Russian research reactors to low-enriched uranium (LEU) has also begun, but it is moving slowly.[13]

In non-Russian former Soviet republics, there are Soviet-supplied research reactors with large amounts of HEU. For example, a shutdown research reactor in Latvia is reported to have enough HEU to make five nuclear weapons. Ukrainian research reactors have significant stocks of HEU as well.[14] These reactors have also been part of the US-sponsored MPC&A program. Some sites in Eastern Europe that were once in the Soviet Union or in territories of Warsaw Pact allies of the Soviet Union have received physical protection assistance from Western European countries and through IAEA-organized advisory and technical assistance programs.[15]

What about the rest of the world? Making progress is a US program started in 1978, the Reduced Enrichment in Research and Test Reactors (RERTR) program, to convert US-supplied foreign research reactors to LEU. In 1993, after that program had been halted for a few years, about a third of the more than 25,000 kg of the US-supplied HEU in these foreign research reactors had been returned to the US.[16] The program was renewed in 1996. In that year, US estimates suggested that 37 of 42 US-supplied HEU foreign research reactors had been converted to LEU, were being converted, had been shut down or would eventually be shut down.[17] But work has been delayed by technical and funding problems. By the early 2002, only 20 of the US-supplied research reactors had been fully converted to LEU.[18] A parallel program by Russia to convert the many Russian-supplied foreign research reactors to LEU is just starting -- with US assistance. HEU-fueled research reactors remain dangerously insecure in many countries around the world.[19] And the failure of both the US and Russia to convert all of their own research reactors to LEU sets a bad example for other countries. For instance, Germany has decided to build a new research reactor near Munich, designed to use 300 kg of HEU, enough for a number of bombs.

Terrorist acquisition of research-reactor HEU to make bombs remains a major threat. HEU research reactors outnumber LEU reactors in Africa, the Middle East, Eastern Europe, Russia and in the industrialized countries of the Pacific.[20] The Vinca reactor in what is now Serbia has some 50 kg of Soviet-supplied fresh HEU and 10 kg of low-irradiated HEU. About two kilograms of HEU disappeared from a research reactor in Sukhumi, in the former Soviet republic of Georgia, during the political unrest there from 1992 to1997. It has not been found.[21] In 1998, members of a smuggling ring were arrested in Italy with uranium enriched to 19.9 per cent U-235 that had been stolen from a research reactor in the Congo.[22] After the 1991 Gulf War, the IAEA inspection team in Iraq found that Iraq's scientists had been trying to make a bomb out of both fresh and irradiated HEU from an Iraqi research reactor.[23] Even in European Union countries and the US, there has sometimes been lax security for research reactors containing HEU. For example, after September

11, outsiders with false identity documents were allowed access to research reactor facilities in the Netherlands, and were not apprehended until they had gotten inside.[24]

3.What level of physical protection is generally afforded to HEU for research reactors?
The discussion above suggests that actual practices for protecting HEU in research reactors are inadequate in some countries. Set forth below are descriptions of norms used for judging physical protection: first, the US government's civilian research reactor protection rules, and second, the IAEA recommendations. Then we compare actual practices for protection of research reactors around the world based on the information countries have supplied to us on a confidential basis in responding to a questionnaire.

Nuclear Regulatory Commission Rules
In the US, the Nuclear Regulatory Commission regulates some 30 of what it calls "non-power reactors" located at universities and industrial plants where they are used for research, testing and training. It reports that it inspects these at least once per year. It has fairly strict requirements for protection of research reactor HEU in quantities of 5 kg or more.[25] This is the quantity also used to define the HEU of greatest concern in the IAEA recommended standards and in our questionnaire, both discussed below. Under the NRC rules, the designers of physical security barriers against theft and sabotage of research reactor HEU must design security measures to protect against a major threat, a "design basis threat" such as a violent, external assault or attempted theft by stealth. They must assume a group of several attackers armed with hand guns, automatic weapons and explosives, a group that may include dedicated individuals with military training and skills who are helped by cooperating insiders who have knowledge of where the HEU is and how to disarm theft alarms. Requirements for protection described in the NRC rules include:

- HEU of 5 kg or more should be stored or processed in a material access area (often called an "*inner area*") within an outer *protected* area. Each of these two areas should have its own strong fence and be surrounded by a lighted area where no one can hide. Access should be controlled to each area to keep out unauthorized people. The areas should be protected by intrusion alarms, which are regularly tested.

- HEU of this quantity which is not "in process" in the reactor should be stored in a vault or vault room monitored by armed guards and sensors with an intrusion alarm. The vault should be inside an inner area within the protected area. HEU in process in a reactor may be use within an outer area. Small pieces of HEU scrap may be stored in a separately locked and fenced area protected by guards or intrusion alarms.

- Access to the inner area should be under the control of authorized individuals and limited to those who require such access to perform their duties. Access to the vault should be limited to personnel who are cleared through full-field background investigations and accompanied by another such person. This should be enforced by armed guards, who are trained to deal with the postulated threats described above, and whose competence is checked periodically in exercises like war games.

- Packages must be searched for explosives and firearms before they are permitted within inner areas, and for nuclear material before they are permitted out.

IAEA Recommendations

These are set out below in bulleted paragraphs that are comparable in purpose to the equivalent bulleted paragraphs for NRC rules. The IAEA recommendations have been adopted by consensus procedures by expert representatives from many countries. However, no multilateral international agreement requires that they be followed.

The Nuclear Suppliers Guidelines recommend that countries, which supply nuclear material to other countries request that the recipients take the IAEA recommendations into account. However, the Guidelines do not say which version of the IAEA recommendations to follow, and the recommendations have been revised several times over the years. As we shall see, some recipients apply the 1993 version, some the 1999 version, and one, both versions. Some suppliers visit the reactors they have supplied to check protections; some do not.

The current recommendations, IAEA INFCIRC 225, Revision 4 (1999), are not as strict in one very important aspect as the NRC regulations briefly summarized above. Unlike the NRC regulations, the IAEA recommendations do not specify any "design-basis threat" against which HEU of more than 5 kilograms must be guarded. While calling the definition of such a threat "essential," Revision 4 leaves that definition up to each country.

We will summarize the strongest IAEA recommendations for uranium protection, those for HEU of 5 or more kg in quantity, the same category of HEU covered by the comparable NRC rules:

- HEU of these amounts should be stored or used only within an *inner* area within an outer *protected* area. "The ceiling, walls and floor of inner areas should provide penetration delay" against unauthorized removal of the HEU. The protected area should be surrounded by a "physical barrier" and clear areas should be provided on both sides of the barrier "with illumination sufficient for assessment." "Access to and the number of access points into the protected area and inner areas should be kept to the minimum necessary." "Intrusion detection sensors" should be recorded and should annunciate to a continuously staffed central alarm station.

- "Storage areas [for HEU] should be of the 'strong room' type in design and should be located in an inner area. They should be continuously locked and alarms activated when not occupied." Operating research reactors (with more than five kg of HEU) should apparently be within the inner area, not just within the outer protected area. (As in the NRC regulations, smaller quantities of HEU, or reactors operating with less, can be in within the outer protected areas.)

- Access to both the protected area and the inner areas "should be limited to persons whose trustworthiness has been determined. [No description of investigation, if any, necessary for this clearance.] …[T]emporary repair, service or construction workers or visitors should be escorted by a person authorized [to have] unescorted access." Access to HEU storage areas "should be strictly limited to assigned persons and to others only when under escort." "A

24-hour guarding service should be provided. …Guards should be trained …When guards are not armed, compensating measures should be applied. The objective should be the arrival of adequately armed response forces in time to counter armed attacks and prevent the unauthorized removal of nuclear material." [No recommendation for exercises like "war games" to test guards and other personnel.]

- "All persons and packages entering or leaving inner areas should be subject to search…"

Except for the failure to specify any "design-basis threat," to recommend "war games" or to call for armed guards for inner areas, these IAEA recommendations appear to be as strong as the NRC requirements. Indeed, in recommending that research reactors operating with more than 5 kg of HEU be located within inner areas, they are stronger. They are, however, only recommendations without even a specified minimum threat.

Actual Practices of Physical Protection

Finding out what actual country practices are has been difficult because practices are confidential; potential thieves who found out where the weaknesses are could use their knowledge to acquire HEU from the reactors or their storage facilities. At Stanford, we developed a questionnaire on physical protection for HEU and asked many countries to complete it on a confidential basis. We have answers from eight and not all of them answered all of the questions. The countries were located in Latin America, Europe, Central Asia, the Pacific and South Asia. None of the respondents lived where they would not be aware of some form of terrorism in their own or nearby countries. Each was asked to answer questions on how they protected five kg or more of HEU at one facility. One respondent answered though stating that the facility had less than that amount. Except for one question for which this amount was not relevant, we did not consider that response. Another respondent no longer had an operating research reactor or any HEU at his site but answered the questions based on what his practices had been when he did. We used his responses.

Five of respondent countries said that they had agreed with their HEU suppliers that they would take the IAEA recommendations for physical protection of the HEU into account, as suggested by the Nuclear Suppliers' Guidelines. These Guidelines do not say, however, whether to take into account the 1993 Revision 3 or the 1999 Revision 4. Major changes were made in 1999. Two of the seven who answered this question said they took Revision 3 into account, four reported Revision 4, and one reported both. This alone suggests considerable variation in practices.

Each of the eight countries that responded to our questionnaire said that they had a national regulatory system that required licensing of facilities such as research reactors containing HEU. But only four reported that the system required inspections of these facilities at least once a year.

What threats did they perceive to their HEU? The questionnaire asked whether they thought the threat of "armed attack by outlaw, terrorist or military unit on the facility and removal of the material by force if necessary" was high for facilities with HEU. Two of the five who answered this question said that it was. These two plus one other ranked as high the threat of *theft* by outsiders as a result of a "single knowledgeable insider, acting voluntarily in collusion with armed outsiders." Two of these three plus one more for a total of *four* out of five who responded to this question ranked "involuntary" collusion by an insider with armed outsiders intending to steal HEU as a fairly high threat for their HEU. Thus, for four of the eight, the threat perceptions are variations on the major threat of armed violence described in the NRC requirements that American research reactors with more than five kg of HEU must be prepared to meet.

Three of these four were the countries with the considerable experience with nuclear reactors and with some significant economic development (though two of these would be classed as "developing" rather than "developed"). The fourth had less nuclear and economic development but had had experience at home with civil conflict of major proportions.

There was great variation in the level of protection the respondents described (fences, walls, doors, windows, etc.) for the outer *protected area* inside of which was the *inner area* where highly-enriched uranium was stored and usually used. For example, one country's respondent confirmed that this outer area could be accessed by climbing over walls or walking around the end of a fence or by crawling through a duct through a wall or something similar. One said his protection was stronger: Access only by crossing over a single fence line, crashing through a light-weight gate, or breaking down a non-reinforced door or window and the like. Four respondents chose still stronger protection as best reflecting their practices: Access only by crossing two or more fence lines, crashing a heavy gate, breaking a reinforced door or window, etc. One had protection so strong that an invader couldn't even get to the outside of the *inner* area where the HEU was stored without first getting through the outer *protected* area's heavily reinforced barriers including active measures such as "vehicle traps or pop-up barriers, man-trap, booby traps, and/or obscurants."

For the *inner areas* (typically buildings) where the HEU should be stored, areas inside the outer *protected area*, all said there were guards, at least during working hours. But two did not provide guns for the guards. Three said that during unoccupied hours there were "standard locks or better at critical access points" – but no guards. Another three (and these had more nuclear experience and more resources) said they had "ID actuated locks or better" at such access points. Only three of the six answering the question about intrusion detection systems at the perimeter of the *outer* "protected area" said that they could detect intruders approaching that area but still outside it. Only one country, perhaps the poorest of the six answering this question, had no penetration sensors even to protect the barrier for the "*inner* area" where the HEU should be kept. Another less-developed country with somewhat more resources and more nuclear experience admitted that penetration sensors were missing from some of its inner area barriers. Only two of the seven respondents answering this question had strong electronic security sensors such as closed-circuit TV as part of its alarm system to detect intruders. These two and two others with considerable nuclear experience and at least some significant economic development had central intrusion alarm stations to respond to detection, and inner-area and outer protected-area intrusion alarms. But not all of these had emergency power systems in case the regular power that operated the various alarm systems was interrupted by terrorists or thieves.

What can we conclude from these responses? Well-developed countries that rely on nuclear power for a significant portion of their electric supply and that have seen terrorism and/or nuclear theft in their own country or nearby seem to have the strongest physical protection. Less well-developed but not poverty-stricken countries, which have fairly well established nuclear research reactor infrastructures (two had no power reactors) and have also seen terrorism and/or nuclear theft at home or nearby have the next best protection. Very poor countries with more limited research-reactor and no power-reactor experience did least well, even though terrorism was not far away for them. Thus financial ability and significant nuclear experience (often going together) seem most important, perhaps even more important than awareness of nearby terrorist threats to HEU.

These variations confirm the conclusions of the experts from several countries who conducted the first ten missions to provide advice and assistance on physical protection to requesting countries under the IAEA's IPPAS program, "International Physical Protection Advisory Service." Based on their experience, they concluded that physical protection "will vary from State to State. Differences in culture, perceived threat, financial and technical resources, and national laws are some of the reasons for variations."[26]

4. Conclusion

We have described the danger that HEU from research reactors can be used to make bombs, the norms required in the US and recommended by the IAEA for protection of five kg or more of research reactor HEU, and the great variation from country to country in actual practices for protection of this quantity of HEU. There is no treaty or other multilateral instrument requiring specific standards of protection from theft of HEU used in research reactors. The one treaty requiring specific physical protection standards is limited in its application to nuclear materials in international transport.[27] Recommendations to extend the treaty to uranium and plutonium used domestically have been made for many years.[28] An IAEA-convened meeting of country experts reached a consensus in 2001 that the treaty should be amended to apply domestically, but efforts to produce an agreed amendment have focused on drafts that contain no specific required standards for domestic protection. The result will be that the variation in practices shown by this paper will continue. Indeed, no amendment would probably be better than one that has no required protection standards because a weak amendment would put off negotiation of a stronger amendment for many years.

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[1] Howard Baker and Lloyd Cutler, *A Report Card on the Depatment of Energy's Nonproliferation Programs with Russia*, (Draft Final Report of Russia Task Force of Secretary of Energy's Russia Task Force), reprinted in Yonah Alexander and Milton Hoenig, *Super Terrorism: Biological, Chemical and Nuclear* (Ardsley, NY, Transnational Publishers, 2001), p. 163, 166.

[2] DOE, Office of Arms Control and Nonproliferation, *Final Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium,"* DOE/NN-007 (Washington, DC, January 1997), p.vii. Something like 50 kg of HEU is probably necessary for a simple Hiroshima-type bomb. This amount can be cut in half or into thirds or smaller by more complex design such as an implosion weapon.

[3] Based on the credible incidents from the Stanford's Database on Nuclear Smuggling, Theft and Orphan Radiation Sources (DSTO), a total of 42 kg of stolen weapons-usable material was seized from illegal possession. Of these, only about 370 g was plutonium, and the rest was HEU.

[4] G. Bunn, F. Steinhausler, & L Zaitseva, "Strengthening Nuclear Security Against Terrorists and Thieves Through Better Training," *Nonproliferation Review* (Fall-Winter 2001), pp.137, 138-39.

[5] DOE, *FY 2003 Budget Request: Detailed Budget Justifications—Defense Nuclear Nonproliferation* (Washington, DC: 2002), see http://www.cfo.coe.gov/budget/oebudget/content/defnn/nuclnonp.pdf, p.172; The 20,000 kg figure is from D. Albright, F. Berkhout, and W. Walker, *Plutonium and Highly Enriched Uranium 1996* (Oxford, UK: Oxford U. Press for Stockholm International Peace Research Institute, 1997), p.398.

[6] IAEA, *Nuclear Research Reactors in the World,* IAEA-RDS-3/13 (Vienna: IAEA, 2000); Iain Ritchie, "Growing Dimensions: Spent Fuel Management in Research Reactors," *IAEA Bulletin* 40 (March 1998), http://www.iaea.or.at/worldatom/Periodicals/Bulletin/Bull401/article7.html>; Bunn, Steinhausler & Zaitseva, *op,cit.*, p.139.

[7] See the Database on Nuclear Smuggling, Theft and Orphan Radiation Sources (DSTO), Center for International Security and Cooperation, Institute of International Studies, Stanford University (2002).

[8] R.L. Civiak, *Closing the Gaps: Securing Highly Enriched Uranium in the Former Soviet Union and Eastern Europe,* (Federation of American Scientists: 2002), p.17.

[9] DOE, FY 2003 Congressional Budget Reguest, Defense Nuclear Nonproliferation/International Material Protection Control and Accounting/Material Consolidation and Conversion and Civilian Sites.

[10] Ibid.

[11] Civiak, *op cit.*, p.23.

[12] See National Intelligence Council, *Annual Report to Congress on the Safety and Security of Russian Nuclear Facilities and Military Forces* (2002), pp. 2, 12; J.B. Wolfstahl, C-A. Chuen, E.E. Daughtry, eds., *Nuclear Status Report*, (Monterey Institute of International Studies and Carnegie Endowment for International Peace, 2001), Chap.4.

[13] F. von Hippel, "Recommendations for Preventing Nuclear Terrorism," *Journal of the Federation of American Scientists,* (November/December 2001), p.7.

[14] E.E. Daughtry & F.L. Wehling, "Cooperative Efforts to Secure Fissile Material in the NIS," *Nonproliferation Review* (Spring 2000), p. 97, 100, 102-104; Wolfstahl, Chuen & Daughtry, *op. cit.*, p166.

[15] IAEA Working Group of the Informal Open-Ended Expert Meetings to Discuss Whether There is a Need to Revise the Convention on the Physical Protection of Nuclear Material, Secretariat Papers no. 8 "IAEA International Physical Protection Advisory Service (IPPAS) Programme, and no. 15 (2000), "Bilateral Physical Protection Support—Compilation of Input from Member States (2000)."

[16] The largest amount of this was in EU countries plus Japan and Canada. Other countries included Argentina, Australia, Austria, Brazil, Chile, Columbia, Iran, Philippines, Romania, Slovenia, South Africa, South Korea, Sweden, Switzerland, Taiwan, Thailand, and Turkey. M. Knapik, "DOE Drafting Policy on Taking Back HEU Fuel from Non-U.S. Reators," *Nuclear Fuel*, April 12, 1993, p. 14.

[17] U.S. Department of Energy, Record of Decision of Final Environmental Impact Statement on Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Fuel, May 17, 1996, ,http://www.emm.doe.gov/rod/; A.J. Kuperman, "Civilian Highly Enriched Uranium and Fissile Material Convention: Codifying the Phase-Out of Bomb-Grade Fuel for Research Reactors," Symposium on "The Scope of a Fissile Material Convention," U.N. Institute for Disarmament Research and Oxford Research Group, Geneva, Switzerland, August 29, 1996. <http//www.nci.org/i/ib82996.htm>

[18] A. Travelli, "Progress of the RERTR Program in 2001," International Conference on Research Reactor Fuel Management," Ghent, Belgium, March 2002.

[19] M. Bunn, J.P. Holdren and A. Wier, *Securing Nuclear Weapons and Materials: Seven Steps for Immediate Action* (Cambridge, MA: Project on Managing the Atom: Belfer Center for Science and International Affairs, 2002), p. iv, 45.

[20] I. Ritchie, "Technical and Administrative Preparations Required for Shipment of Research Reactor Spent Fuel to its Country of Origin," International Atomic Energy Agency-Argonne National Laboratory Training Course, Lecture L.1.2 (January 1997), text at figures 8, 9, 10.

[21] Daughtry & Wehling, *op.cit.,* 100.

[22] See Bunn, Steinhausler and Zaitseva, *op.cit.,*p.139.

[23] See IAEA, *Fourth Consolodated Report of the Director General of the IAEA Under Paragraph 16 of Security Council Resolution 1051* (1996), IAEA Doc. S/1997/779 (Vienna, Austria, Oct. 8, 1997); A. Travelli, "Status and Progress of the RERTR Program in the Year 2000," International Meeting on Reduced Enrichment for Research and Test Reactors, Las Vegas, Nevada, Oct. 2000.

[24] Eric van Staten, "Two Strangers Were Caught with False Identities," *De Telegraaf* , Amsterdam, September 28, 200; see Bunn, Steinhausler and Zaitseva, *op.cit.,* p. 139-41.

[25] 10 U.S. Code of Federal Regulations, Part 73, Sec. 73.1(a)(2), 73.2, 73.40, 73.50, 73.60, 73.67

[26] Mark Soo Hoo, David Ek, Axel Hageman, Terry Jenkins, Chris Pace, Bernard Weiss, "International Physical Protection Advisory Service: Observations and Recommendations for Improvement," *Proceedings of the 42nd Annual INMM Meeing* (Northbrook, IL: INMM, July, 2000)

[27] Convention on Physical Protection of Nuclear Material, Annex 1. The treaty entered into force in 1987. See IAEA Information Circular, 274, Annex 1.

[28] See, e.g, G. Bunn, "International Arrangements against Nuclear Terrorism," in P. Leventhal & Y. Alexander, *Preventing Nuclear Terrorism* (Lexington Books, Lexinton, MA. 1987). p. 339; G. Bunn, "Physical Protection of Nuclear Materials: Strengthening Global Norms,", *IAEA Bulletin*, v.39, no.4, (1997), p. 4.